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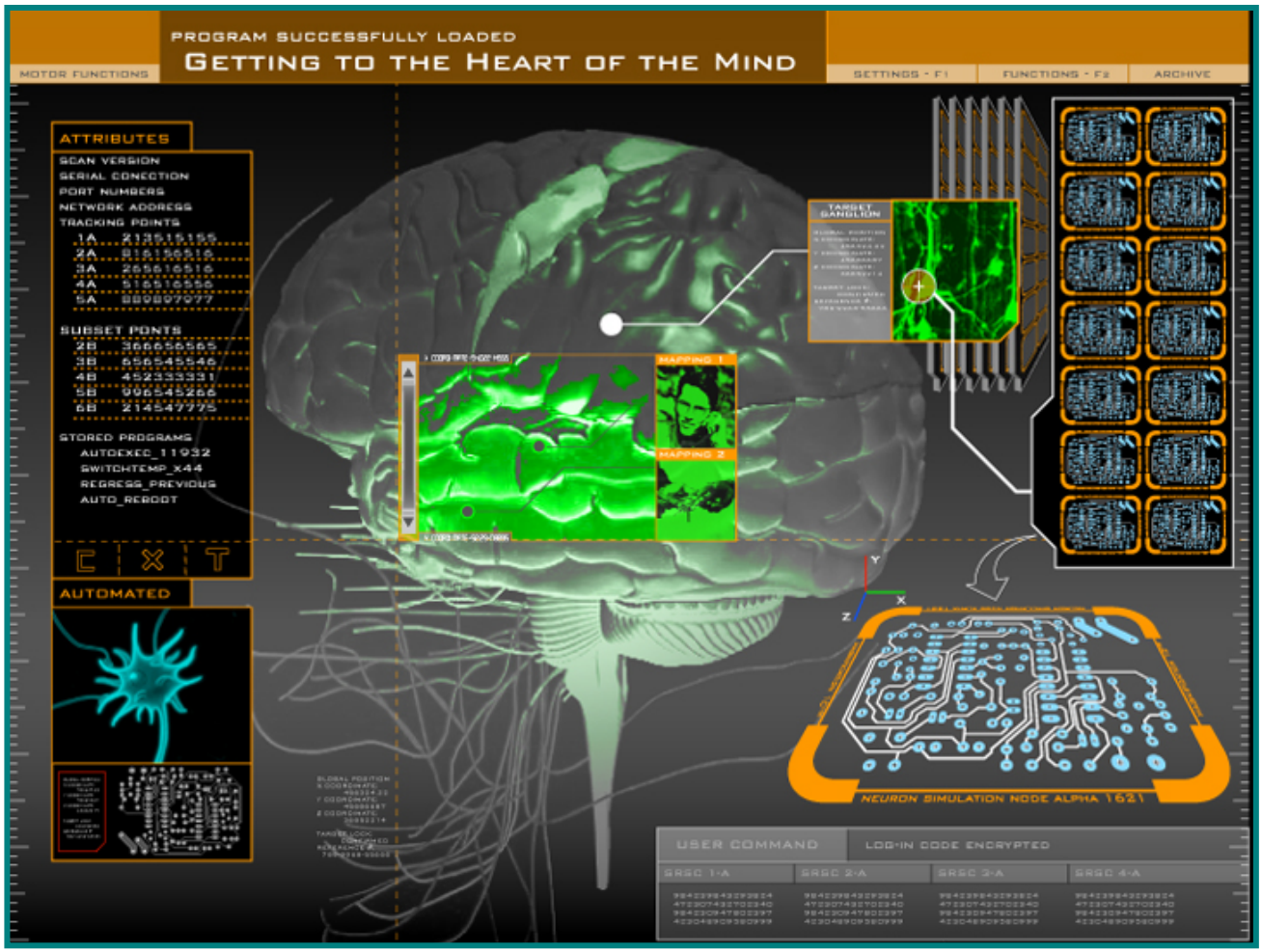
Getting to the Heart of the Mind

"Getting to the Heart of the Mind." I'd like to come back to the theme that Ron Brachman set forth in his opening remarks: the power of the human mind and how vital it is to dealing with complex, real-world situations. To paraphrase Ron, the human mind can reason, collaborate, and respond to new situations. It can deal with uncertainties, recall past experiences that apply to the current situation, and perhaps most remarkably, it can adapt and learn so that its performance is always improving. To date, no machine we have ever built has come close to achieving those capabilities.

Three years ago, IPTO embarked on an ambitious mission to create a new generation of cognitive computing systems that could begin to emulate some of the mind's most important functions. Our vision was to get to the heart of the mind by creating cognitive technologies that begin to do the kind of knowledge acquisition, reasoning, flexible problem solving in new situations, and learning and creativity that characterize human cognitive capabilities.



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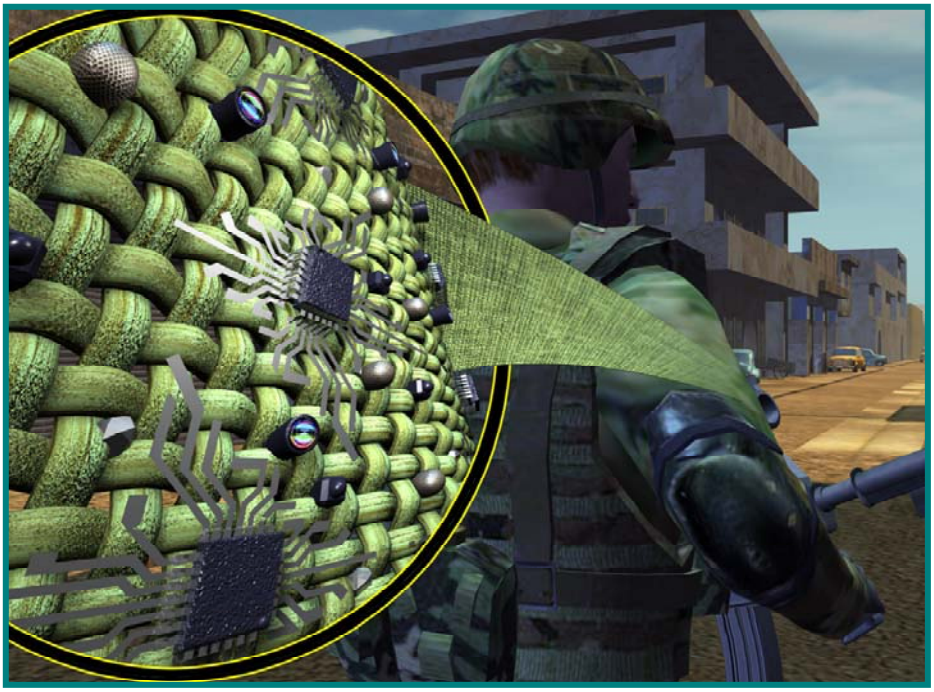
To remind you of what we said last year, IPTO is in the midst of a renaissance. We have redefined who we are and what we do. In the past, through driving national needs combined with extraordinary creativity, IPTO created the computer revolution that now pervades every aspect of our daily lives. We are again at a crossroads filled with critical national needs and unprecedented opportunities for revolutionary change in the way we acquire, process, and communicate information.

As you've heard from our program managers, we've come a long way from the early days of that grand dream. We now have a portfolio of programs that are aggressively tackling key components of cognition. The previous talks are but a few examples of this. Mari Maeda addressed the fundamental issues of sensing, experiencing, and creating coherent communicable memories from these experiences. Joe Olive dealt with communication, in particular, the critical need for translating foreign speech and text into English and distilling their essence so commanders and warfighters can tell the relevant information at a glance. Dave Gunning addressed the integration of learning and reasoning, from the fundamental science of neural- and cognitive-inspired architectures to the system level of the PAL program. And Tom Wagner talked about how to extend individual cognition to an area critical to war-fighting: namely, the issue of teamwork with shared plans and intentions. We are beginning to close in on and scale some of the critical hurdles to achieving our grand dream. But there is much more to do.

As we forge ahead in creating new cognitive capabilities, we need to ask ourselves where we would like to be in 20 years. What should our far-term vision be?

Let me paint a picture of the future. Special Operations Forces take on adversaries in an urban setting. Through comprehensive immersive simulations, replete with heat, dust, cultural accuracy, bad odors, and a hostile populace, our warfighters are well prepared for what their adversaries are likely to do under a variety of attack scenarios. They have shared situational awareness anytime they need it from a variety of sources. So if one warfighter or one unit discovers critical tactical information, that information is pushed at the appropriate level of detail to the right parties. Among the sources of information could be multiple sensor systems, which might include intelligent collectives of tiny, mobile entities—like smart flies on the wall. The warfighters will know in advance the building layout and their adversaries' whereabouts, weaponry, and intentions. Imagine they have robot partner teams that can add to their situational awareness and perform hazardous missions, such as resupply from remote stockades; they can serve as willing "pack mules" or distract the adversary when needed. The



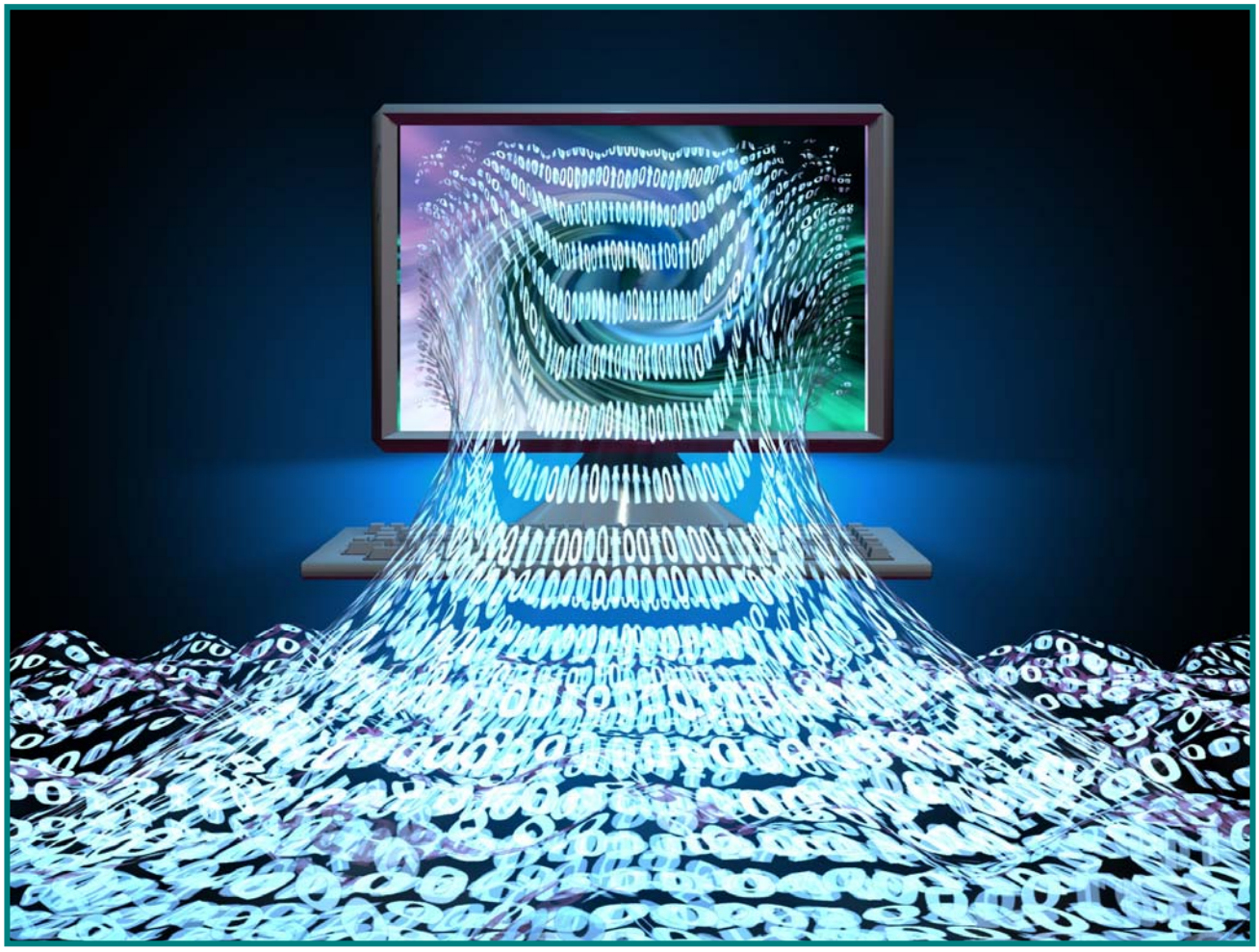
warfighter's clothing is more than just clothing; it's an extended skin with sensors, hands-off, unfettered information processing and covert communications intricately integrated into its fabric.

They can track friendly and hostile forces without lifting a finger and, perhaps, without even having to utter a command. And if it becomes necessary to use force, their extended skin and weapons can adapt to their needs. They can change their sphere of interest at will to determine where they need to focus their attention. And they can "shape" their weapons to fit the situation as it evolves.

Once the traditional battles are over, a new phase of stabilization and reconstruction begins. The entire spectrum of friendly forces must now engage in different activities that can benefit immensely from cognitive systems. Patrolling warfighters will need to communicate with local civilians in multiple languages and dialects using advanced natural-language devices. At higher levels, large-scale cognitive technology can help create robust enterprise software systems to aid in maintaining infrastructure, and providing security and warning services.

There are many futures like this that we can imagine. The picture I've painted doesn't even begin to address all the challenging problems our warfighters of the future will encounter. But the point I want to get across is, as we go forward with our cognitive systems programs, it's time for us to think about the larger picture of where we want to be in a future where information systems truly become our partners.

To create the kind of highly-capable cognitive systems our warfighters of the future will depend on, we need to drive system integration as a fundamental science, both vertically and horizontally. As is abundantly clear from the



previous talks, no single, individual technology is sufficient to solve the increasingly complex problems facing DoD. You can't just throw petaflops at a problem and expect it to be solved. You can't expect machine learning by itself to learn deeply if it isn't coupled to reasoning and knowledge. As Tom Wagner said, "We are not alone." And as Mari Maeda and Joe Olive made totally clear, communication is a key to providing a whole that is greater than the sum of the parts.

As you've heard from Dr. Holland, it is imperative that we invest in the vertical layers of computing foundations, from novel hardware architectures to high-productivity language environments. And as you heard from our program managers, individual cognitive technologies need to cooperate horizontally to scale the barrier of what Dave Gunning calls "machine stupidity."

We need to integrate the individual cognitive and information processing technologies we are developing into highly-capable cognitive systems that can provide the warfighter with a coherent picture of the right information at the right time. Our next great challenge is to leap ahead in cognitive systems by making technology integration a reality. This means bringing together technical communities that have traditionally remained separate. We need to exploit enormous creativity you can generate at the fertile interfaces of multiple, complementary technologies. We've come a long way, but we need your fresh, new ideas as we continue to create the next information processing revolution. With your help, we can truly get to the heart of the mind.